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The observation of face centred cubic Gd, Tb, Dy, Ho, Er and Tm in the form of thin films and their oxidation

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Abstract. High energy transmission electron diffraction and microscope studies have been made of the following rare earth metals, Gd, Tb, Dy, Ho, Er and Tm, the films being made by means of vapour deposition.

The thinnest films had face centred cubic structures whereas in the thicker films the hexagonal close packed structures of the metals in bulk form were observed.

Oxidation of the films was observed in the vacuum in which they were deposited and also under the influence of the electron beam of the electron microscope.

The lattice parameters of the face centred cubic forms of Gd, Tb, Dy, Ho, Er and Tm were found respectively to be 5·40, 5·20, 5·18, 5·15, 5·09 and 5·06 Å the error being about ±1%.

1. Introduction

The rare earth metals under consideration normally have a hexagonal close packed structure when in bulk form (Spedding and Beaudry 1971). It was recently observed that vacuum deposited erbium has a face centred cubic structure in thin films (Curzon and Chlebek 1972) hence it was considered worthwhile to determine whether other rare earth metals would behave in a similar manner. All the metals studied (Gd, Tb, Dy, Ho, Er and Tm) were in fact found to have face centred cubic forms in thin films.

2. Experimental procedure

The rare earth films studied in the present experiments were prepared in a vacuum coating unit which operated at about 10^{-6} Torr. The metals were of industrial grade and were supplied by the American Potash and Chemical Corporation. They were evaporated from a molybdenum filament and the vapour was condensed on thin carbon films supported on electron microscope grids. A shutter between the vapour source and substrate enabled condensation of the metal to be started and stopped at any convenient time. With the exception of gadolinium the metals under consideration acted as getters hence when evaporation started the pressure in the vacuum system generally fell by about a factor of ten. This being the case the metal vapour was in most cases not allowed to condense on the substrate until the pressure had first dropped. A marked gettering

action was not observed for gadolinium and in fact the pressure usually rose slightly during evaporation of this metal.

After a metal film was made it was coated with a thin film of vacuum deposited carbon. The final specimen on a microscope grid therefore consisted of a thin film of a rare earth metal sandwiched between two thin carbon films. When the specimen was removed from the vacuum coating unit and transferred to a Philips EM 300 electron microscope the carbon coatings reduced to a minimum the possibility of oxidation by exposure of the specimen to the atmosphere. In the case of the earlier work on erbium (Curzon and Chlebek 1972) a protective coat of carbon was not applied after the metal had been deposited. It was considered that the erbium would rapidly become coated by a thin layer of oxide when the metal was exposed to air and this oxide would prevent oxidation of the entire metal. Electron diffraction studies failed to reveal the presence of oxide in films which were not protected with carbon and hence showed that the above suggested protection mechanism based on a surface oxide film operated reasonably effectively.

The results of an experiment now to be described show that the carbon coating was very effective for reducing oxidation. A layer of carbon was deposited on a glass slide and then two silver electrodes were vapour deposited on the carbon, one at each end of the slide. The electrical resistance of the carbon film was too high to be measured. When a thin film of a rare earth metal was deposited the electrical resistance rapidly dropped to a measurable level even for very thin films showing that the rare earth films become continuous at relatively thin average thickness. As soon as air was admitted to the coating unit the electrical resistance of the metal film rapidly increased by one or two orders of magnitude showing that the film was much affected by the air. Since in the experiments on erbium (Curzon and Chlebek 1972) extensive diffraction patterns from erbium oxide were not observed in the erbium films exposed to air in this way it is deduced that the increase in resistance was associated with changes in electrical continuity caused by surface oxidation of metal crystallites especially at grain boundaries and was not due to total conversion of the relatively good conducting metal to poorly conducting oxide. When a layer of carbon was deposited on a film of a rare earth metal immediately after the metal had been condensed on the carbon substrate the response of the specimen to exposure to the atmosphere was quite different. The resistance of the specimen only increased by a factor of two or less when exposed to the air instead of by one or two orders of magnitude as had been the case for unprotected films. Unless otherwise stated the results discussed below were obtained from metal films which were protected on both sides by thin layers of carbon.

3. Results

The metals Gd, Tb, Dy, Ho, Er and Tm all formed polycrystalline face centred cubic films when the deposits were thin. In thick films the normal hexagonal close packed structures were observed. The lattice parameters a_0 of the face centred cubic forms which are given in table 1 were obtained by using thallium chloride as calibration material, the thallium chloride being vapour deposited onto films of the metals. Also appearing in table 1 are the nearest neighbour distances $a_0/\sqrt{2}$ in the cubic structures and the a spacing of the hexagonal structures (Spedding and Beaudry 1971). The c/a ratio for the hexagonal structures is not $\sqrt{8}/\sqrt{3}$ hence these structures do not correspond exactly to the close packing of

Table 1. Lattice parameters in Å for rare earth metals and their oxides

Metal	a_0	$a_0/\sqrt{2}$	a	Oxide	b_0	c_0
Gd	5·40	3·82	3·634	Gd_2O_3	10·77	10·81
Tb	5·20	3·68	3·601	Tb_2O_3	10·71	10·73
Dy	5·18	3·66	3·592	Dy_2O_3	10·62	10·67
Ho	5·15	3·64	3·578	Ho_2O_3	10·56	10·61
Er	5·09	3·60	3·559	Er_2O_3	10·55	10·55
Tm	5·06	3·58	3·538	Tm_2O_3	10·46	10·49

a_0 is the lattice parameter of face centred cubic metals observed in thin films; a is the lattice parameter of hexagonal close packed metal observed in bulk (Spedding and Beaudry 1971); b_0 are the parameters of the cubic oxides of the rare earth metals observed in the present work; c_0 are the lattice parameters of the cubic oxides of the rare earth metals reported by Templeton and Dauben (1954) or by Guth and Eyring (1954).

spheres. If the rare earth atoms could be regarded as spheres then it would be expected that

$$a_0/\sqrt{2} = a.$$

As may be seen from the table, $a_0/\sqrt{2}$ is 1–2% larger than a for all of the metals studied except for gadolinium where the difference is 5%. The values of a_0 were measured to about 1% hence it is thought that the result for gadolinium does not differ from the results for the other metals because of measuring error but because a real effect exists. The difference is thought to be due to oxygen contamination in gadolinium. When gadolinium is evaporated it does not act as a getter hence the chance of contamination is higher, in fact, in some regions of the gadolinium specimen, oxide rings could be observed. It was pointed out in previous work on face centred cubic erbium (Curzon and Chlebek 1972) that oxidation leads to a slight rearrangement of the erbium atoms but basically the erbium lattice remains almost face centred cubic with a lattice parameter which is four per cent bigger than in the pure metal. A similar state of affairs applies to gadolinium. The observed lattice parameter of 5·40 Å is probably larger than it should be because of oxygen contamination, the oxygen not being present in sufficient quantities to lead to a well defined oxide structure with prominent oxide diffraction rings.

Further support for the suggestion that the observed lattice parameter of face centred cubic gadolinium may be slightly larger because of oxygen contamination is afforded by the fact that the lattice parameters of the face centred cubic forms of all the other metals listed in table 1 increase by about 2% if these metals are deposited in poor vacuum, that is in a vacuum where the gettering effect has not reached maximum efficiency.

The values of a_0 listed in table 1 were obtained from electron diffraction patterns taken with the 100 kV electron beam operating at low intensity. When the intensity was increased the crystal size increased and very large oxide crystals formed. This is thought to be due to the heating effect of the electron beam. The lattice parameters b_0 of the oxides which have cubic crystal structures could be measured to about $\frac{1}{2}$% because the diffraction patterns were extensive and the rings were sharp. The results agree well with those obtained by x ray methods (Templeton and Dauben 1954 and Guth and Eyring 1954).

The thicknesses at which the cubic form of the rare earth metals occur has not been studied with the exception erbium. By using the inverse square law and the mass of erbium evaporated to calculate the thickness it was found that a film about 140 Å thick contained only face centred cubic erbium whereas a film 195 Å thick contained both the face centred cubic and hexagonal forms. In thick films only hexagonal close packed

erbium was observed. Though the thicknesses of films of the other metals was not known in Å the relative thicknesses of the films of a given metal could be obtained from their optical transmission. In all cases the face centred cubic form was observed in thin films and as film thickness increased so the hexagonal form became predominant.

The Philips EM 300 electron microscope used in the present studies is equipped with an evaporator which enables metals to be condensed on substrates inside the microscope (Curzon 1971). In view of the reactivity of the rare earth metals it was considered inadvisable to evaporate large quantities of the metals in the microscope, however, a few studies were made with erbium. It was found that in thin films the face centred cubic phase was observed and as the films became thicker so the normal hexagonal phase of bulk erbium became predominant, that is, the results were the same as those obtained from erbium films made in the vacuum coating unit and sandwiched between carbon films. All the metals studied were chemically similar hence the result for erbium also indicated that for the other metals the observation of face centred cubic forms in thin films does not depend on whether the films are prepared in the electron microscope or a vacuum coating unit.

4. Discussion

When a new phase is observed for a metal in the form of a thin film it is important to establish whether the material examined is the metal itself or whether it is a chemical compound which occurs because of contamination of the film. The films studied had metallic reflectivity, the low electrical resistance of metal films and transformed into oxides when heated under an intense electron beam. All of these facts strongly suggest that the new phases were metallic. A further argument in favour of this conclusion is afforded by the thickness dependence of the structures of the films. As was stated earlier, condensation on a substrate was not allowed to begin until the gettering action had reduced the ambient pressure to a steady minimum. In this situation the rate of arrival of atoms of the metal being studied at the substrate was approximately constant as was the rate of arrival of atoms from contaminants in the vacuum. In thin films face centred cubic phases were observed whereas in thick films the normal hexagonal structures of the metals in bulk were observed. The measured lattice parameters of the hexagonal forms agreed within the experimental error of about 1% with x ray results (Spedding and Beaudry 1971) which indicates that in thick films the concentration of contaminants was not large enough to be detected. Since the thin films and the thick films were made in the same way and the thick films behaved as relatively uncontaminated metals it must be concluded that the face centred cubic phases observed in thin films were new phases of the metals and not compounds of the metals. Had they been compounds of the metals there is no reason why the same compounds should not have been seen in thicker films.

All the experimental results reported so far for Tb, Dy, Ho, Er and Tm are completely consistent with the suggestion that the face centred cubic phases which are associated with these metals are new forms of the metals. No result obtained for these phases requires an explanation in terms of a compound of a rare earth metal and a contaminant in the vacuum such as oxygen or nitrogen. In the case of gadolinium there is some evidence to indicate that the films were contaminated with oxygen. Since the films possessed marked metallic properties and strong electron diffraction rings from the usual oxide Gd_2O_3 were not observed it is reasonable to assume that even in this case

the face centred cubic phase is characteristic of metallic gadolinium in thin films, though in order to be absolutely sure of this it would be necessary to condense the gadolinium in a better vacuum than was available for the present experiments.

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References

Curzon A E 1971 *Rev. Sci. Instrum.* **42** 545–6
Curzon A E and Chlebek H G 1972 *J. Less Common Metals* **27** 411–5
Guth D E and Eyring L 1954 *J. Am. Chem. Soc.* **76** 5242–4
Spedding F H and Beaudry B J 1971 *J. Less Common Metals* **25** 61–73
Templeton D H and Dauben C H 1954 *J. Am. Chem. Soc.* **76** 5237–9